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I am pleased to join the Subcommittee to discuss and demonstrate how technological convergence is today supporting delivery of advanced features and services to wireless customers. The rapid deployment of two national and several regional broadband wide-area wireless networks, the increasing computing power and memory resident in today's wireless devices, and diverse software applications now available for these Internet-connected wireless devices have combined to efficiently deliver new multimedia applications and services in a mobile, rather than fixed or hot spot, environment. These Internet Protocol (IP) enabled applications include, but are not limited, to video streaming, video on demand, digital imaging, gaming, location based services, high speed Internet access, e-medicine, e-government, e-medicine, education, and many more.

The rapid deployment of these services and their wide availability to the American people are in part the result of US telecommunications policies that have reallocated substantial new spectrum to commercial licensed use, permitted licensees flexibility in the utilization of that spectrum, and maintained a single national authority at the Federal Communications Commission (FCC) for the regulation of wireless services in the United States. Over the past fifteen years, the pro-competitive, technology neutral policies, coupled with a general "hands-off" approach to government regulation of the

Internet, has allowed the wireless industry to grow rapidly to a point where currently over 170 million Americans subscribe to wireless services.

Advanced Wireless Networks Provide National and Regional High-Speed Access

The first key driver of wireless convergence is the current and accelerating deployment of regional and national high speed wireless networks using third-generation (3G) code-division multiple access (CDMA) technology on licensed spectrum. These networks are providing ubiquitous network access to IP services wherever and whenever customers need to connect. Around the world, wireless operators are deploying 3G wireless systems based on CDMA technology including WCDMA/UMTS and CDMA2000 1X and CDMA2000 1xEV-DO. These national and regional deployments are significant because they are providing customers reliable wide-area wireless access to broadband services over licensed spectrum.

For example, in the case of WCDMA/UMTS, although commercial network launches have really only begun in earnest over the past 12 months, we see that over 60 regional or national networks have been launched to date in dozens of countries in Europe and Asia, with over 16 million subscribers globally at the end of 2004. These subscribers enjoy wide-area wireless access at peak data speeds of 384 kbps. These WCDMA deployments will accelerate rapidly in 2005, and we will soon see WCDMA wide-area networks throughout much of the developed world, and the addition of many millions of WCDMA subscribers globally in nations and regions where wireless access is economically the best option for broadband internet connectivity.

In the case of CDMA2000 1xEV-DO (also referred to as EV-DO), deployed for over two years in South Korea, then across Japan, and now being rapidly deployed across the U.S., over 11 million subscribers currently enjoy peak data rates of 2.4 Mbps on 16 networks in Asia and the Americas. In the United States, Verizon Wireless has launched EV-DO in over 30 major metropolitan markets, a footprint that extends service to over 75 million Americans. It is notable too that these wide-area deployments do not represent a disparate set of individual "hot spots," but rather large contiguous service areas featuring seamless hand-offs and seamless roaming, not only between EV-DO equipped cell sites but also to CDMA2000 1X service at the boundaries of EV-DO coverage.

The significance of these networks for technology convergence is that wireless devices can now maintain reliable high-speed wireless connectivity over wide-area regional and national footprints deployed on licensed spectrum. For example, a business traveler taking the metroliner train from Washington, DC to New York City can maintain a high-speed wireless data connection continuously during her entire trip. Using this connection, this traveler can access her corporate intra-net as well as the Internet and other applications while fully mobile just as if she were working in her office.

It is important to note here that these national and regional wireless networks are deployed in licensed spectrum. There has been much discussion recently of the benefits of unlicensed spectrum and services, with some advocating that the U.S. government allocate additional prime, high-value spectrum (that spectrum below 1 GHz) to unlicensed use. At QUALCOMM, we are heavy users of local-area network unlicensed wireless services on our campus, and nation-wide users of wide-area licensed wireless services when we are off our campus now on a fixed monthly charge, "all-we-can-eat"

basis. I think that our example illustrates the complementary nature of unlicensed and licensed wireless services – unlicensed is useful in the local area, like an individual office suite that is not prone to significant interference from other unlicensed users, while licensed wireless services are needed to provide wide area service everywhere else. As national and regional wide-area network are playing and will continue to play a crucial role in meeting the Internet connectivity needs of American citizens, I recommend that the Congress maintain and expand spectrum currently allocated for licensed wide-area use and seek to clear and auction that spectrum as soon as possible.

Economics and protection from interference plays an important role here. It costs billions of dollars to build out a national or regional wireless network. Corporations are not prepared to make that level of investment without certainty that they will be able to serve customers at the expected level of service quality without the threat of harmful interference. In an unlicensed regime, no one can be sure that they will be able to sell a wireless service even in a local area without the threat of harmful interference from another unlicensed operator or device. I believe that it is this uncertainly that has dampened commercial enthusiasm for project like the "Cometa" unlicensed network that was proposed by a well-financed team of major corporations but then ultimately abandoned.

Those of us who build and operate commercial licensed wireless systems also worry about the impact of unlicensed "overlays" and "underlays" in spectrum licensed for commercial mobile radio systems. Our research indicates that operation of these devices impacts the accuracy of the GPS measurements taken by our cellphones when E-911 calls are placed, and similarly impacts the call quality particularly in certain coverage

areas. What is especially difficult for network operators is that they might experience inference from an unlicensed wireless device (which generates a customer complaint), and by the time they can get a technician into the field to investigate the complaint, the source of interference has moved on, leaving them unable to diagnose and correct the problem.

Some observers have also suggested that "smart" or "cognitive" radios can permit multiple unlicensed and licensed devices to share spectrum. At QUALCOMM we have conducted research and examined the literature in this area, and found such capability to be complex and expensive and not of dependable reliability. Without proven results and standards, there will always be a commercial incentive for individuals and businesses to take short cuts when fielding devices that depend on intelligence to avoid interference, resulting in more interference in a particular location than anyone planned or that the government authorized. Since, as we noted earlier, it is difficult to locate and police sources of harmful interference, we may end up in a situation where network performance is intermittently impaired and we are unable to diagnose and correct it.

Modern CDMA wireless networks that are enabling the advancements we are discussing today operate efficiently at low power levels. They can rapidly lose capacity and performance and require higher transmitted power in an effort to overcome interference from unlicensed devices. Efficient, low power systems, both cellular and GPS, are by their nature more susceptible to interference than higher power, less efficient systems. Given the enthusiasm in some quarters for unlicensed wide-area services, I feel the need to urge the limitation of unlicensed uses to local area, low power uses to protect existing and planned services over wide-area licensed systems from harmful interference.

The Processing Power & Functionality in Wireless Devices Enable Advanced Services

The growing processing power and functionality in the chips inside wireless handsets are also contributing substantially to convergence. CDMA wireless handsets are now increasingly smaller and faster devices that can deliver and receive voice, music, video and 3D graphics. These features enable wireless subscribers to enjoy useful, interactive applications and services on their phones. We will soon deliver a chipset that will enable a wireless device to roam across multiple 3G networks – permitting a global convergence of wireless access.

As a point of reference, the processing power of the chipsets that power today's advanced cell phones trail the processing power of personal computers by only a few years. That is to say, the new cell phone in your pocket today has the computing power of the desktop PC you might have purchased only two or three years ago. And that trend is continuing. With the 7000 series of cellphone chipsets that QUALCOMM announced this year, dubbed the "convergence platform," cellphone manufacturers will have access to dual processors on a single chipset, and that chipset will enable phones to provide the following advanced features:

- Two-way video streaming – smooth, high resolution video streaming at 30 frames per second (the same frame replacement rate as your TV at home).
- Outstanding audio quality for MP3 features and surround sound.
- Extreme 3D graphics – up to 4 million triangles per second and 7 million 3D pixels per second for game-counsole quality graphics.
- 6.0 Megapixel camera – for high quality imaging.

- Position location using GPS coupled with high resolution maps.
- VGA – improved high resolution display.
- Support of ancillary devices for medical monitoring and security

These features will support services such as: point-to-point video telephony for mobile conferencing, interactive gaming, downloadable feature-length movies, downloadable music, streaming video, photos, and more. Because these functionalities are resident on the chipset, handset manufacturers will be able to build wireless devices with these capabilities in the same form factors that customers expect in their wireless devices today.

This new chipset series will also support multiple 2G and 3G standards including all major common air interfaces, including:

- CDMA2000 1X
- CDMA2000 1xEV-DO Rev 0 and Rev A
- IS-95 A/B
- WCDMA (UMTS)/HSDPA
- GSM/GPRS/EDGE

Since the chipsets powering wireless devices will operate on the major 3G networks in use globally, these networks will also "converge" in that customers will enjoy ubiquitous high-speed data services regardless of location or of the 3G air interface provided in a specific location.

A notable present example of the "convergence" of new capabilities enabled by 3G CDMA data networks and high-speed processors in cell phones is the "V CAST"

service launched this month by Verizon Wireless. The V CAST service uses Verizon Wireless's EV-DO high speed data network to download media content including:

- High-quality video-on-demand of;
    - current news, weather, sports and entertainment programming
    - music videos and short programs specifically designed for mobile phones, and
- 3D games.

Using V CAST, customers can also download branded video content such as:

- News Corp. and 20th Century Fox,
- "24: Conspiracy," "Sunset Hotel" and "Love & Hate" – specifically designed for mobile phones,
- NBC newscasts made exclusively for mobile phones, and
- MTV Networks' VH1, Comedy Central

The V CAST service supports the downloads of video clips of up to 5 minutes in length, with high quality sound and video with the same 30 second video frame replacement rate used for traditional television. As an example of the continuing convergence of services enabled by wireless networks and devices, last week Verizon Wireless and Warner Music Group announced the launch of the nation's first mobile music video download service on V CAST. Using this service, Warner Music will be the first major music company to make its music video catalog of artists available for download to consumers in the U.S. on their wireless phones.

I have given you examples of wireless handset features that will inform and entertain, but the wireless industry is also working hard to deploy features that will

enhance both the personal security of individual customers and also our collective homeland security. The most important of these safety features is wireless enhanced 911 (E-911). I say this because the National Emergency Numbering Association reports that wireless customers dial "911" on their wireless phones over 120,000 times each day in the United States. I am pleased to report that according to official reports filed in at the FCC by wireless operators, at least 1,628 public safety answering points in the US (these are the 911 dispatch centers) are equipped to receive E-911 position location data from wireless phones. Fully 136 million people live in the cities and counties served by these dispatch centers, which are spread over 39 states. In a recent report to the FCC, Sprint PCS reported that they have now sold a total of 33 million wireless phones equipped with GPS position location to locate wireless customers when they dial "911" in an emergency. The deployment in the near future of streaming video capabilities on wireless phones will permit emergency personnel to not only tell the hospital about a patient's injuries but also to show the doctor in real time exactly what they are observing at a rescue site.

Software Downloads Bring Desktop Functionality to Mobile Environment

The software used by these wireless handsets and networks is also contributing to the convergence of rich and diverse services. An example of how software advancements and facilitating technological convergence is QUALCOMM's BREW[1] platform. Using BREW-enabled handsets, wireless customers are able to download and operate software applications in a mobile setting that heretofore could only by utilized on stationary desktop computers. By utilizing BREW to make more applications available to wireless customers, we have observed an explosion in new access, including over 200 million

[1] Binary Runtime Environment for Wireless

cumulative individual BREW application downloads by November of 2004. These applications downloaded to wireless devices that are BREW-enabled include:

- Communications - instant messaging, email, photo sharing, greeting cards and other interactive message delivery,
- Location - mapping, navigation, traffic, city guides and other position location specific content,
- Productivity - mobile address/contacts synchronization to office applications and helpful tools that increase personal efficiency,
- Games - single-player and interactive multi-player games,
- m-Commerce - financial transactions such as account balance, point-of-purchase, product/merchandise purchase, stock trades and more,
- Entertainment - ring tones, music, video, comics, screen savers, wall papers,
- Information - flight tracking, news, weather, sports and other magazine-oriented content.

BREW enables access to these multiple applications by serving as a common platform for wireless applications. Sitting "on top" of a phone's chip system software, the BREW platform has access to chip-level features allowing it to download and run applications directly on the phone. By dynamically allocating the phone's random access memory for applications as they are running and by using local storage and processing the BREW platform optimizes the phone's memory allocation.

Advancements in Wireless Multimedia Capabilities Will Continue

Advancements in multimedia convergence over wireless systems will only accelerate over time. For example, QUALCOMM recently announced plans for a subsidiary (MediaFLO USA) to deploy and operate a nationwide "mediacast" network, delivering many channels of high-quality video and audio programming to third-generation mobile phones at mass market prices. QUALCOMM intends to offer the network as a shared resource for U.S. CDMA2000 and WCDMA cellular operators, enabling them to deliver mobile interactive multimedia to their wireless subscribers without the cost of network deployment and operation.

Subscribers to this service will enjoy access to a broad range of high-quality content from the entertainment industry's leading media companies. MediaFLO USA will aggregate and distribute the content that is available to all MediaFLO partners and will provide seamless integration of this content with unique content that individual operators provide to maintain their competitive differentiation. The system will give TV stations and networks, cable TV and satellite operators and networks, and other content providers a major new distribution channel that complements their current offerings, enabling them to reach their audiences when they are away from home and on the go. U.S. consumers will gain access to compelling media services whenever and wherever they want them.

The nationwide mediacasting network will deliver multimedia content to wireless mobile devices in the 700 MHz spectrum for which QUALCOMM holds licenses covering the entire nation. The network will support 50-100 national and local content channels, including up to 15 live streaming channels and numerous clip-cast and audio

channels. This content will be delivered in an easy-to-use and familiar format at quality levels that dramatically surpass current mobile multimedia offerings through the use of QVGA video at up to 30 frames per second and high-quality stereo audio. I should point out here, however, that QUALCOMM will not be able to deploy this service nationally until the broadcasters who currently are operating in channel 55 complete their conversion to digital and relinquish their analog channel. Since this conversion is moving at a pace that is much slower than Congress anticipated when it enacted its digital transition plan, we believe that a new hard end date in statute will be required to ensure that the transition moves forward and the public can enjoy these new services.

Advancements Will Allow VoIP Over Wireless Data Networks

QUALCOMM recently announced enhancements to current CDMA2000 EV-DO networks that will enable rich wireless multimedia services such as high-speed transfer of bandwidth-intensive files (including high-quality pictures, video and music), interactive 3D gaming as well as multicasting services.

Revision A to CDMA2000 1xEV-DO supports peak data rates of 3.1 Mbps on the forward link and 1.8 Mbps on the reverse link, 192 forward-link and reverse-link channels and four-way receive diversity, delivering eight times the user capacity compared to EV-DO Revision 0. Optimized for packet data service, Revision A provides one of the lowest costs per bit when compared with other wireless wide area network (WAN) technologies. CDMA2000 EV-DO Revision A also includes support for low-latency applications, including a variety of IP-based services such as Voice over Internet Protocol (VoIP) and real-time conversational services such as push to talk, video telephony and instant multimedia — an extension of push to talk that combines

immediate voice with simultaneous delivery of video and pictures, offered over a cellular and/or PCS platform. As a result, VoIP will not be only a desktop phenomenon - advanced wireless networks using the technologies we have discussed today will enable mobile wireless VoIP delivering high quality and high capacity while lowering capital and operating costs.

National Policies to Help Facilitate These Advancements

To facilitate this digital convergence and the delivery of additional Internet Protocol enabled services over wireless networks the US Congress can:

1. Make more spectrum available for advanced wireless services by establishing in law a hard end date of December 31, 2006 to end the digital TV transition.
2. Maintain the current allocations of licensed wireless spectrum below 1 GHz.
3. Ensure that before unlicensed devices are permitted to operate in licensed spectrum that there is clear and convincing proof that they will not cause harmful interference to the licensed services.
4. Encourage the FCC not to impose any regulatory barriers that impede the delivery of VoIP over PCS or cellular platforms.

Support of the policy goals listed above will ensure that the operators that deliver advanced wireless services have access to the additional spectrum necessary to carry multimedia services like video to wireless devices. These policies have enabled wireless operators to quickly evolve the technologies used on specific bands of licensed spectrum without the need for any new approvals from the FCC, and to deliver new Internet based services to wireless devices without the need for government involvement. The result is that Americans now enjoy access to the fastest national wireless network in the world,

and wireless devices with the richest feature sets available anywhere. These policies will ensure that wireless networks and technologies can "converge" as rapidly as possible, yielding the greatest benefits to American consumers and to our national economy.

Dr. Irwin Mark Jacobs

Dr. Irwin Mark Jacobs is co-founder, chairman and CEO of QUALCOMM Incorporated, pioneer and world leader of Code Division Multiple Access (CDMA) digital wireless technology. Dr. Jacobs has led the commercialization of CDMA technology and its success as the world's fastest-growing, most advanced voice and data wireless communications technology. Now used by over 227 million consumers worldwide, CDMA is the technology of choice for third-generation wireless communications services.

Dr. Jacobs holds several CDMA patents, contributing to QUALCOMM's extensive portfolio of more than 3,000 issued and pending U.S. patent applications. More than 125 companies have licensed CDMA for the manufacturing of wireless devices and network infrastructure equipment, integrated circuits and test equipment.

Dr. Jacobs previously served as co-founder, president, chairman and CEO of LINKABIT Corporation, directing it's growth from a few part-time employees in 1969 to over 1,400 employees in 1985, and first introduction of Ku-band Very Small Aperature Earth Terminals (VSATs), commercial TDMA wireless phones, and the VideoCipher® satellite-to-home TVsystem. LINKABIT merged with M/A-COM in August 1980, at which time Dr. Jacobs served on the company's board of directors until he resigned from M/A-COM in April 1985. Over 35 San Diego communications companies trace their roots back to LINKABIT.

From 1959 to 1966, Dr. Jacobs was an assistant/associate professor of electrical engineering at Massachusetts Institute of Technology (MIT). From 1966 to 1972 he served as a professor of computer science and engineering at the University of California, San Diego (UCSD). At MIT, Dr. Jacobs co-authored a basic textbook in digital communications entitled, Principles of Communication Engineering. First published in 1965, the book remains in use today.

Dr. Jacobs is the recipient of numerous industry, education and business awards, including:

Woodrow Wilson Award for Corporate Citizenship, Woodrow Wilson International Center for Scholars, May 2004
Dorothy I. Height Chair's Award, Leadership Council on Civil Rights, May 2004
Dr. Morris Chang Exemplary Leadership Award, The Fabless Semiconductor Association (FSA), December 2003
Eta Kappa Nu Eminent Member Award, Electrical & Computer Engineering Honor Society, November 2003
Tau Beta Pi Distinguished Alumnus Award, Tau Beta Pi Engineering Honor Society, October 2003
International Engineering Consortium Fellow Award, November 2002
Innovation Award in Communication, The Economist, September 18, 2002
Honorary Doctorate, University of Pennsylvania, May 13, 2002

American Academy of Arts and Sciences Fellow, April 2001
Bower Award in Business Leadership, the Franklin Institute, April 2001
Honorary Doctorate, Technion University, June 5, 2000
Golden State Award, Board of Directors of the California Council for International Trade, May 2000
Scientist of the Year Award, Achievement Rewards for College Scientists (ARCS), April 2000
Radio Communication Report (RCR) Wireless Hall of Fame Inductee, for his significant contributions to the advancement of the wireless telecommunications industry, March 2000
Director of the Year Award for Enhancement of Economic Values, the Corporate Directors Forum, February 2000
1999 Ernst & Young Leadership Award for Global Integration, Computerworld Smithsonian Award Program, 1999
Medal of Achievement Award, The American Electronics Association (AEA), 1998
Entrepreneur of the Year in the Master Entrepreneur category, RCR, 1996
Person of the Year Award, RCR, 1996
The Albert Einstein Award, the American Society of Technion, 1996
IEEE Alexander Graham Bell Medal, IEEE, 1995
Cornell's Entrepreneur of 1994
The National Medal of Technology Award (the highest award bestowed by the President of the United States for extraordinary achievements in the commercialization of technology, or the development of human resources, that foster technology commercialization), 1994
Inventing America's Future Award, AEA, 1993
The International Citizens Award, World Affairs Council of San Diego, 1993
The San Diego Business Leader of the Year Award, San Diego Venture Group, 1993
Entrepreneur of the Year Award, The Institute of American Entrepreneurs, 1992
First Annual ExcEL Award, the local AEA, 1989
Distinguished Community Service Award, the Anti-Defamation League of B'nai B'rith, 1984
Election to the National Academy of Engineering, 1982
Biannual award "for an outstanding contribution to aerospace communications," the American Institute of Aeronautics and Astronautics (AIAA) 1980 (Drs. Jacobs and Andrew Viterbi were jointly honored)

Dr. Jacobs received a bachelor's degree in electrical engineering in 1956 from Cornell University and master of science and doctor of science degrees in electrical engineering from MIT in 1957 and 1959, respectively.

Dr. Jacobs is a member of a number of industry and community boards and committees. He is a Fellow of the IEEE and a member of Sigma XI, Phi Kappa Phi, Eta Kappa Nu, and Tau Beta Pi. Dr. Jacobs also serves on the Council on Competitiveness, the National Academy of Engineering Committee on Public Awareness of Engineering, the board of

directors of Building Engineering & Science Talent, the visiting committee of the MIT Laboratory for Information and Decision Systems, California Council on Science and Technology, and is past chairman of the University of California President's Engineering Advisory Council.